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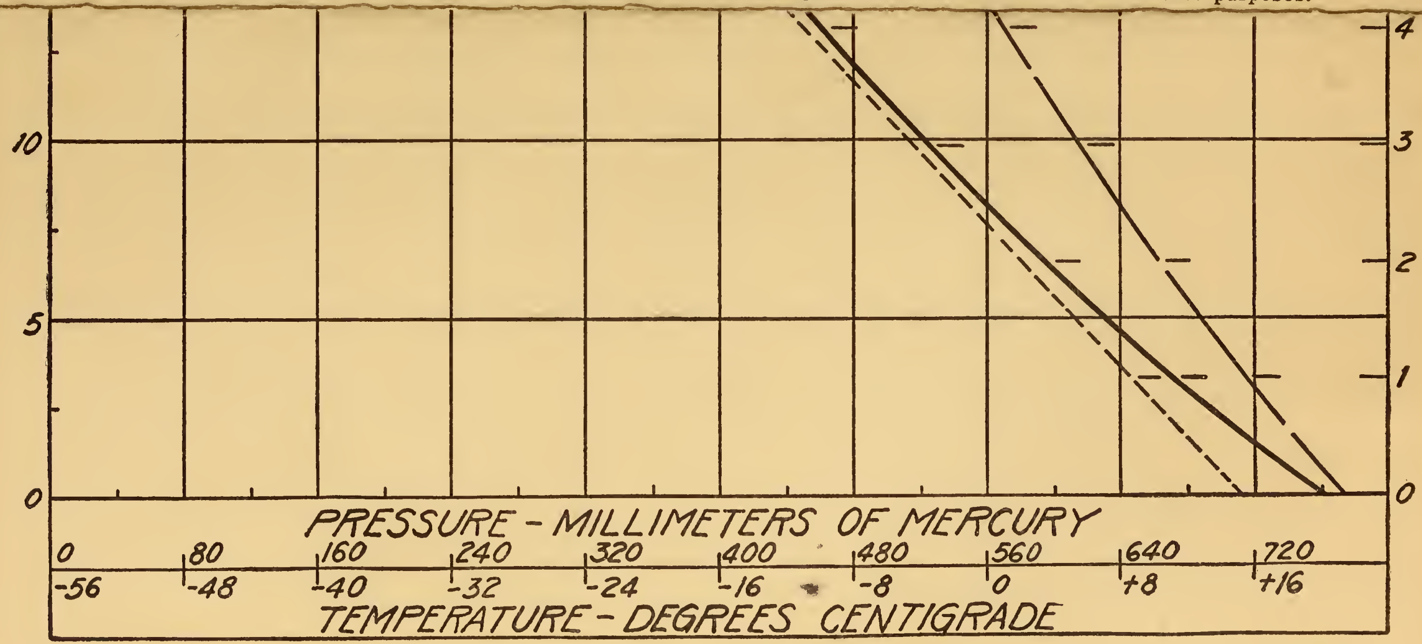
DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

Miscellaneous Publication
of the Bureau of Standards
No. 82
(Supersedes M 78)

Standard Atmosphere Chart

Officially adopted by all interested United States Government organizations for aeronautics and related purposes.



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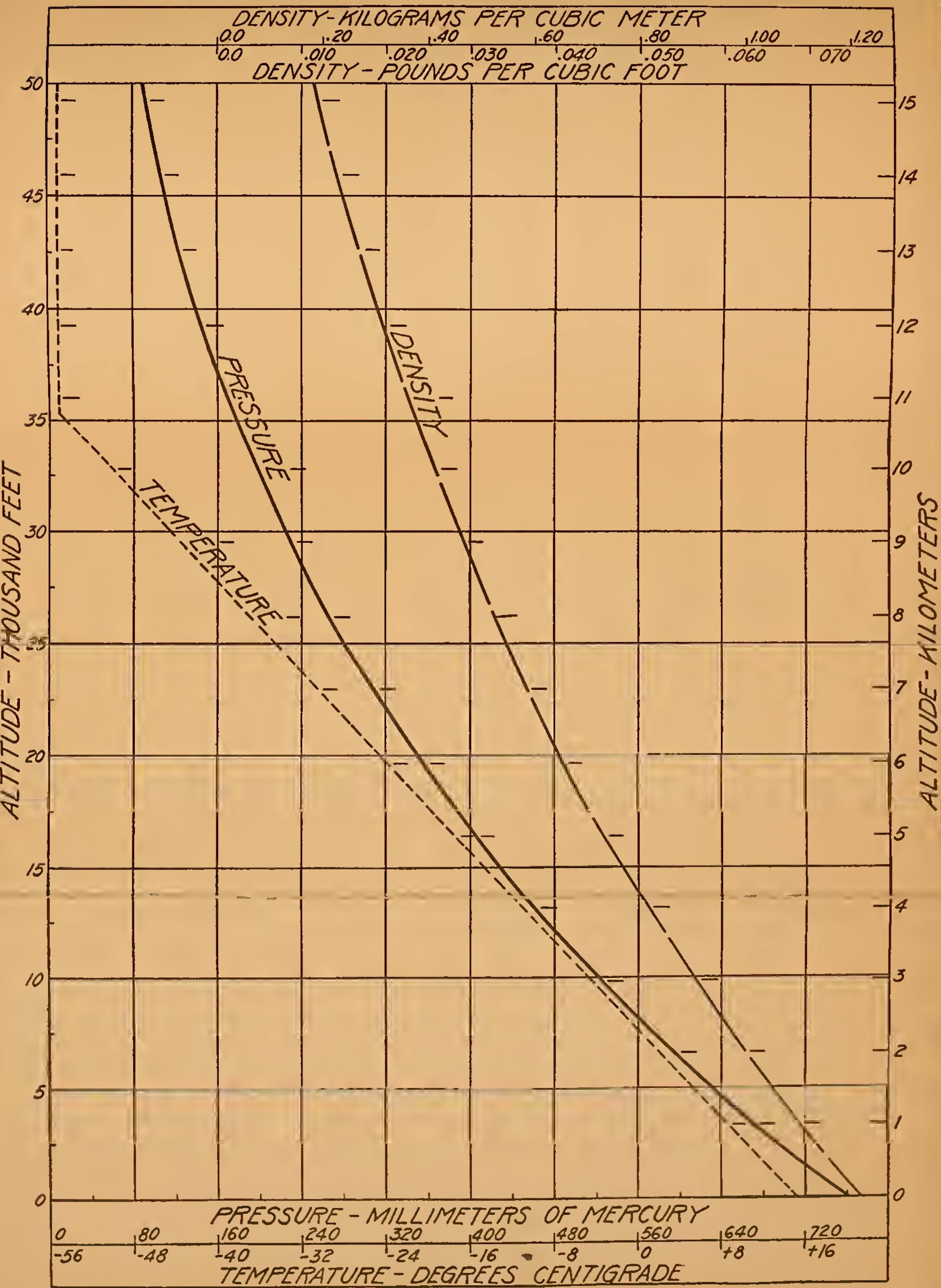

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STANDARD ATMOSPHERE

By W. G. BROMBACHER, Physicist

In aeronautics a standard atmosphere is an assumed condition of the atmosphere which is defined by an altitude-temperature-pressure relation. The chief difference among the various atmospheres which have been proposed lies in the selection of the altitude-temperature relation. A standard atmosphere is an aeronautic necessity in evaluating the performance of airplanes and for the calibration of instruments. For example, the performance of an airplane, such as its rate of climb or ceiling, in order to be comparable with that of other machines is stated in terms of altitudes which correspond to the same standard conditions of air temperature, pressure, and density. Further, altimeters are pressure-measuring instruments graduated in terms of altitude according to the altitude-pressure relation of a standard atmosphere. Air-speed indicators are calibrated to indicate true air speed at a standard air density. The results of wind-tunnel investigations are also reduced to a standard density of air.

A standard atmosphere has been officially adopted for use in the United States for the above and other aeronautic purposes by the following Government organizations: Army Air Corps, Bureau of Standards, National Advisory Committee for Aeronautics, Navy Bureau of Aeronautics, and the Weather Bureau. This atmosphere is now in general use throughout the United States in aeronautics except in the evaluation of the altitude of flights made to break international records, in which case the Fédération Aéronautique Internationale standard atmosphere is the basis of comparison. The altitude-temperature assumption of the United States standard is a slight modification of that

(*b*) Up to the isothermal layer (below 10,769 m)

$$T = 288 - aZ \tag{3}$$

$$T_m = \frac{aZ}{\log_e \dfrac{T_o}{T_o - aZ}} \tag{4}$$

$a = 0.0065000$ for Z in meters.
$= 0.0019812$ for Z in feet.

(*c*) At the lower limit of the isothermal layer (10,769 m)

$T = 218°$ absolute $= -55°$ C.
$Z_{55} = 35{,}332$ feet $= 10{,}769$ meters.
$T_{m55} = 251.378°$ absolute.

(*d*) In the isothermal layer (above 10,769 m)
$T = 218°$ absolute $= -55°$ C.

$$T_m = \frac{Z}{\dfrac{Z_{55}}{T_{m55}} + \dfrac{Z - Z_{55}}{218}} \tag{5}$$

In the above formulas

Z = Standard altitude.
Z_{55} = Altitude at the lower limit of the isothermal layer.
T = Absolute temperature of the air at altitude Z.
T_o = Standard sea-level temperature in degrees absolute.
T_m = Mean temperature of the air column below altitude Z in degrees absolute.

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The formulas defining the United States standard atmosphere are given below.

(*a*) For all standard altitudes

$$Z = K\frac{T_m}{T_o}\log_{10}\frac{p_o}{p} \qquad (1)$$

$$\rho = \rho_o\frac{p}{p_o}\frac{T_o}{T} \qquad (2)$$

$T_o = 288°$ absolute $= 15°$ C.

$p_o = 760$ mm of Hg $= 29.921$ in. of Hg.

$K = 19{,}413.3$ for Z in meters.
$= 63{,}691.8$ for Z in feet.

$\rho_o = 1.2255$ for ρ in kg/m³.
$= 0.07651$ for ρ in lbs./ft.³

(*b*) Up to the isothermal layer (below 10,769 m)

$$T = 288 - aZ \qquad (3)$$

$$T_m = \frac{aZ}{\log_e \dfrac{T_o}{T_o - aZ}} \qquad (4)$$

$a = 0.0065000$ for Z in meters.
$= 0.0019812$ for Z in feet.

(*c*) At the lower limit of the isothermal layer (10,769 m)

$T = 218°$ absolute $= -55°$ C.

$Z_{55} = 35{,}332$ feet $= 10{,}769$ meters.

$T_{m55} = 251.378°$ absolute.

(*d*) In the isothermal layer (above 10,769 m)

$T = 218°$ absolute $= -55°$ C.

$$T_m = \frac{Z}{\dfrac{Z_{55}}{T_{m55}} + \dfrac{Z - Z_{55}}{218}} \qquad (5)$$

In the above formulas

Z = Standard altitude.

Z_{55} = Altitude at the lower limit of the isothermal layer.

T = Absolute temperature of the air at altitude Z.

T_o = Standard sea-level temperature in degrees absolute.

T_m = Mean temperature of the air column below altitude Z in degrees absolute.

T_{m55} = Mean temperature in degrees absolute for Z_{55}.

p = Pressure of the air at altitude Z.

p_o = Standard sea-level pressure.

ρ = Density of the air at altitude Z.

ρ_o = Standard density at sea level.

Absolute temperatures are equal to centigrade temperatures plus 273. p is in the same unit of pressure as p_o.

The chart on the reverse of this card gives the temperature, pressure, and density for standard altitudes up to 50,000 feet. A brief table of the values of these quantities is given below. See National Advisory Committee for Aeronautics Technical Reports Nos. 147, 218, and 246 of the committee for further data and complete tables.

Standard Atmosphere Table

Altitude		Pressure		Density		Temperature	Mean temperature
Meters	Feet	mm Hg	in Hg	kg/m³	Lbs./ft.³	°C	°C
0	0	760.0	29.921	1.2255	0.07650	15.0	15.0
1000	3281	674.1	26.54	1.1120	.06942	8.5	11.7
2000	6562	596.2	23.47	1.0068	.06286	+2.0	8.4
3000	9842	525.8	20.70	.9094	.05678	−4.5	5.1
4000	13123	462.3	18.20	.8193	.05115	−11.0	+1.8
5000	16404	405.1	15.95	.7363	.04597	−17.5	−1.6
6000	19685	353.8	13.93	.6598	.04119	−24.0	−5.0
7000	22966	307.9	12.12	.5896	.03681	−30.5	−8.4
8000	26247	266.9	10.51	.5252	.03279	−37.0	−11.9
9000	29528	230.4	9.07	.4664	.02912	−43.5	−15.4
10000	32808	198.2	7.80	.4127	.02577	−50.0	−18.9
11000	36089	169.7	6.68	.3614	.02256	−55.0	−22.4
12000	39370	145.0	5.71	.3090	.01929	−55.0	−25.5
13000	42651	124.0	4.88	.2642	.01649	−55.0	−28.1
14000	45932	106.0	4.17	.2259	.01410	−55.0	−30.2
15000	49212	90.6	3.57	.1931	.01206	−55.0	−32.0
0	0	760.0	29.921	1.2255	.07651	15.0	15.0
1524	5000	632.3	24.89	1.0559	.06592	+5.1	10.0
3048	10000	522.6	20.58	.9048	.05649	−4.8	+5.0
4572	15000	428.8	16.88	.7711	.04814	−14.7	−0.1
6096	20000	349.1	13.75	.6527	.04075	−24.6	−5.3
7620	25000	281.9	11.10	.5489	.03427	−34.5	−10.5
9144	30000	225.6	8.88	.4583	.02861	−44.4	−15.9
10668	35000	178.7	7.04	.3795	.02369	−54.3	−21.3
12192	40000	140.7	5.54	.2998	.01872	−55.0	−26.0
13716	45000	110.8	4.36	.2361	.01474	−55.0	−29.6
15240	50000	87.3	3.44	.1860	.01161	−55.0	−32.4

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